Part II. treats of relations between algebraic quantities (functions, &c.), the theory of numbers (also continued fractions), the combinatory analysis (including probabilities), series and the doctrine of limits, imaginary quantities (operations with the imaginary unit and the geometrical representation of imaginary quantities : note our remarks above on this head under Byerly), the general theory of equations.

The second of Prof. Newcomb's works before us is "Elements of Geometry" (New York, 1881). An article in our columns (NATURE, vol. xxi. p. 293), headed "The Fundamental Definitions and Propositions of Geometry, with especial Reference to the 'Syllabus' of the Association for the Improvement of Geometrical Teaching," gives its readers a hint that some such work as the one before us was even then in the author's mind—"A summary of my own, the latter [*i.e.* the summary] still in an inchoate state." The remarks in this article showed that their writer was well fitted to address himself to the subject of a geometrical text-book, and the execution is not at all inferior to the promise. The ground taken up is the Euclidian geometry as comprised in the treatises of Euclid himself, Legendre, and Chauvenet. As with the "Algebra," here let Prof. Newcomb speak for himself. As he himself says, the question of the best form of development is one of great interest at the present time among both teachers and thinkers. The object not being to teach geometry merely, but the general training of the powers of thought and expression being a main object, Prof. Newcomb considers it most important to guard against habits of loose thought and incomplete expression to which the pupil is prone. This he considers is best secured by teaching the subject on the old lines. The defects he finds in Euclid's system are (1) in the treatment of angular magnitude; here he makes two additions, the explicit definition of the angle which is equal to the sum of two right angles, and the recognition of the sum of two right angles as itself an angle. He adopts, from the "Syllabus," the term "straight angle," though he himself inclined (NATURE, *loc. cit.*) to the use of "flat angle," and considers the German "gestreckte Winkel" to be more expressive. Then (2) the restriction of the definition of plane figures to portions of a plane surface. "In modern geometry figures are considered from a much more general point of view as forms of any kind, whether made up of points, lines, surfaces, or solids." In an appendix, "Notes on the Fundamental Concepts of Geometry" he returns to a consideration of this subject.

Features of the book are (1) the practising the student in the analysis of geometrical relations by means of the eye before instructing him in formal demonstrations; (2) the application of the symmetric properties of figures in demonstrating the fundamental theorem of parallels (*cf.* German methods and Henrici's conguent figures); (3) the analysis of the problems of construction, to lead the pupil to discover the construction himself by reasoning; (4) the division of each demonstration into separate numbered steps, and the statement of each conclusion, where practicable, as a relation between magnitudes; (5) the theorems for exercise have been selected with a view to interesting the student in the study, and the author has endeavoured to graduate them in order of difficulty; (6) some of the first principles of conic sections have been unfolded, more especially for the use of students who do not propose to study analytical treatises on those curves; (7) Euclid's treatment of proportion is "perfectly rigorous, but has the great disadvantages of intolerable prolixity, unfamiliar conceptions, and the non-use of numbers. The system common in American works of treating the subject merely as the algebra of fractions, has the advantage of ease and simplicity." But to this last system there are obvious objections, and our author essays with some reserve, a *via media*. In this part and in the following Prof. Newcomb submits his methods to the judgment of teachers. Feature (8) involves the treatment of the fundamental relations of lines and planes in space. "In presenting it he has been led to follow more closely the line of thought in Euclid than that in modern works. At the same time he is not fully satisfied with his treatment, and conceives that improvements are yet to be made."

It will be gathered that the book covers most of the ground passed over by young students in plane and solid geometry, and conics in their school training. We cordially commend both Prof. Newcomb's works to teachers in this country, and we feel sure they will not regret our having called their attention to them so fully in the author's own words, as they will thus see in what way his books are likely to be helpful to them. We have read them with much interest, and feel sure our readers will endorse our favourable verdict upon them. We need only say that the author considers that the study of geometry as here unfolded can be advantageously commenced at the age of twelve or thirteen years. The volumes, with a third, which we have not seen, on Astronomy, form part of "Newcomb's Mathematical Course."

R. TUCKER

ELECTRICITY AT THE CRYSTAL PALACE

IV.—*Submarine Telegraphy*

IN the stall of the South Eastern Railway Company at the Crystal Palace may be seen a specimen of the first cable core ever submerged. It consists of a slender copper wire coated with gutta-percha, and was prepared at Streatham by Mr. J. Forster. On January 10, 1849, it was submerged by Mr. Walker, at Folkestone, and a copy of the telegram announcing the completion of the work is still preserved. It runs: "I am on board the *Princess Clementine*. I am successful; 12.49 p.m." Next year a cable was laid between Dover and Cape Grisnez by Mr. Wollaston, but lasted only a few hours. Several specimens of it are shown in the Exhibition by the South Eastern Railway Company and the Post Office. The gutta-percha core was quite unprotected, and it was sunk by means of lead weights attached at intervals. Next year a core, protected by hemp and iron sheathing, was laid by Mr. T. R. Crampton between Dover and Cape Grisnez, and proved so successful, that it is still working. Specimens of this cable, which has proved the type of all subsequent ones, are also to be seen.

There are now some 97,200 miles of cable at work in the world, and before this year is ended the hundred thousand miles will have been attained; for the second Jay Gould Atlantic cable is still unfinished, and the s.s. *Silvertown* of the India-rubber and Gutta-percha Telegraph Company is now on her way to lay some two thousand miles on the West Coast of Central America. Nearly all this cable has been made in London, and the Telegraph Construction and Maintenance Company alone has manufactured 65,400 miles, and laid it in almost every sea, in depths varying from shoal water to 3000 fathoms. In 1863 the firm was resolved into the existing Company. Specimens of all the cables made by them are exhibited in a large glass case, together with a large map of the world, showing all the submarine and land lines in existence; those constructed by the Company being marked in red. The most novel feature of their exhibit is, however, a plan for keeping up telegraphic communication between a lightship and the shore. In 1870 an attempt was made to establish a floating telegraph station in the chops of the Channel; an old man-of-war corvette, the *Brisk*, being fitted up, and moored in deep water about sixty miles from the Land's End. It was found, however, that as the ship swung with the tide, the telegraph cable fouled with the ship's riding-chain, and likewise became twisted into kinks, which crushed

the gutta-percha core and destroyed the insulation of the cable Means were taken to prevent this trouble, but as passing ships did not leave a sufficient number of telegrams, the project was abandoned. Nevertheless, it is clear that such a scheme is worthy of further trial; and even with ordinary lightships it is eminently desirable that they should be in telegraphic communication with the nearest Coast Guard Station. At present, guns and rockets are the only available messengers, and when the wind is off the shore, guns are sometimes not heard; or when the weather is thick, rockets are not seen. The result is, that ships are sometimes lost on shoals close by the lightships, without the Lifeboat Station knowing it. Carrier-pigeons have been tried, but these birds fail to make good progress in snow-storms or thick weather, and in heavy gales are driven hither and thither at the mercy of the elements. The plan for cable communication adopted by the Telegraph Construction and Maintenance Company is to moor the lightships by chains to two mushroom anchors sunk a considerable distance apart. One of these chains is made double, and the cable runs through the middle of it between the double links, as shown in Fig. 1. The chains meet at a mooring swivel, which is made so as to allow the cable to pass through it, as shown in Fig. 2. Between the swivel and the bow sheave of the ship, a revolving joint in the cable, designed by Mr. Lucas, prevents the cable becoming twisted as the ship swings to the wind and tides. A sufficient length of cable is coiled in a tank on board, for paying out, when from stress of weather it is necessary to employ more chain. A pretty model of a lightship moored on this plan is exhibited by the Company, and on touching a press-button let into the edge of the tank, an electric current is sent through the communicating cable, and strikes a bell on board the ship. It is satisfactory to know that the Trinity House have agreed to test the plan by means of a cable between the *Sunk* lightship moored some eight miles off the Essex coast, and the Post Office of Walton-on-the-Naze, from whence telegrams can be sent by day or night for any assistance required.

Of the total 97,200 miles of cable in the world, some 36,420 are owned and worked by the Eastern Telegraph Company and its affiliated companies the Eastern Extension Telegraph Company and the South African Telegraph Company. The Eastern Telegraph Company is perhaps the most enterprising of cable corporations, and makes a very fine display at the Crystal Palace. Cable operations have been of great assistance to the geographer, and the soundings taken in order to ascertain the nature of the sea-bottom, where a cable route is projected, have enriched our charts quite as much as special voyages. There is, however, another way in which these operations could be made subservient to the cause of natural science; but it is a way which has not been sufficiently taken advantage of. Besides the specimens of stones, mud, and sand, which the sounding-lead brings up from the deep, the cable itself, when hauled up for repairs, after a period of submergence, is frequently swarming with the live inhabitants of the sea-floor—crabs, corals, snakes, molluscs, and fifty other species—as well as overgrown with the weeds and mosses of the bottom. Some attempt was made to describe these captures of the wire, as taken from the tepid seas of the Amazon mouth, by the writer in our pages several years ago (vol. xi. p. 329),[1] and the suggestion was there made that cable repairing might serve as a novel method of dredging; but the hint has probably not been taken, for we cannot learn of any competent naturalist having taken his passage on board a cable-repairing ship, say in the Brazilian and West Indian waters, or better still, the East Indian waters traversed, by the lines of the Eastern and Eastern Extension Telegraph Company, from Aden to Bombay, and from Madras to Penang, Singapore, Batavia, and soon to Port Darwin, in Australia. The result is that cables have again and again been lifted richly vestured with the spoils of the bottom, and many an unknown species has passed over the drums unnoted, to rot and fester in the general mess within the cable tanks. We venture to predict a rare harvest to the first naturalist who will accompany a repairing ship, and provide himself with means to bottle up the specimens which cling to the cable as it is pulled up from the sea.

Some idea of these trophies may be gathered from the stall of the Eastern Telegraph Company, where a few of them are preserved. Two of these are a very fine grey sea-snake, caught on the Saigon cable in a depth of thirty fathoms, and a black and white brindled snake, taken from the Batavian cable in twenty-five fathoms. Twisting round ropes seems to be a habit of this creature, for the writer remembers seeing one scale up a ship's side out in the River Amazon, by the "painter" hanging in the water.

A good example of a feather-star is also shown; these animals, being frequently found grasping the cable by their

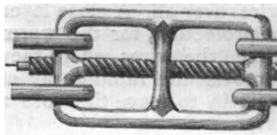

Fig. 1.

Fig. 2.

Fig. 3.

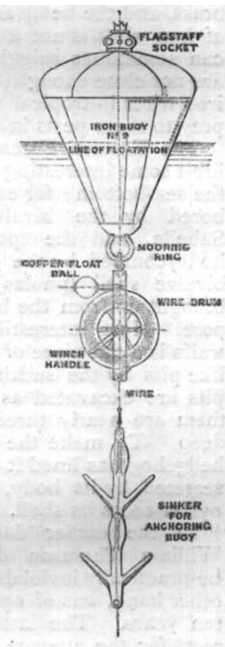

Fig. 4.

tentacles. A handsome specimen of the blanket sponge, picked up in the Bay of Biscay, is also exhibited; but the most interesting object of all is a short piece of cable so beautifully encrusted with shells, serpulæ, and corals, as to be quite invisible. It was picked up and cut out in this condition from one of the Singapore cables. The rapid growth of these corals is surprising, and some valuable information on this head might be gained if the electricians of repairing ships in these eastern waters would only make some simple observations. Curiously enough, so long as the outermost layer of oakum and tar keeps entire, very few shells collect upon the cable, but when the iron wires are laid bare, the incrustation speedily begins, perhaps because a better foothold is afforded.

A deadly enemy to the cable, in the shape of a large boring worm, exists in these Indian seas; and several of them are shown by the Company. The worm is flesh-coloured and slender, of a length from 1½ inches to 2½ inches. The head is provided with two cutting tools, of a curving shape, and it speedily eats its way through the hemp of the sheathing, to the gutta-percha of the core, into which it bores a hole similar to that shown in Fig. 3.

[1] "On some South American Phenomena" (J. Munro).

A full account of this particular worm, with anatomical illustrations, is given in the *Journal* of the Royal Microscopical Society for October, 1881, by Dr. Charles Stewart, secretary of the Society. The bore-holes, after passing through the oakum of the inner sheathing, either pursue a tortuous course along the surface of the gutta-percha core, or go right into the copper wire, thereby causing a "dead earth" fault. Dr. Stewart classes the worm as one of the Eunicidæ, but proposes for it the generic name of *Lithognatha worslei*, because of its possessing a pair of calcareous mandibles or cutting jaws, and after Capt. Worsley, the Commander of the repairing ship which picked up the worm-eaten cable. The pair of calcareous jaws, in addition to three pairs of chitinous ones, is the most remarkable feature about the animal, and the white plates which form them make the creature look as if it were in the act of swallowing a tiny bivalve shell.

The best protection hitherto formed against it is to cover the core with a ribbon of sheet-brass, laid on without a lap. First the gutta-percha is covered with cloth, then the brass is overlaid. Canvas is then put over the brass, and the hemp and iron wires over all. A close layer of iron wires is not a sufficient protection, for the worm can sometimes wriggle in between the wires where they are not close enough; and, moreover, the rapid decay of iron wires in tropical seas is certain to leave the core a prey to these pests in a few years.

The Eastern Extension Telegraph Company also exhibit some interesting samples of stones picked up from the sea-bottom; for example, limestone blocks and shells bored by the bivalve, *Saxicava ragosa*, the worm Sabella, and the sponge *Hymeniacidon celata*; wood honeycombed by the teredo, a red stone pitted by the bivalve shell (pholas), and a ferruginous flaky stone brought up from the bottom between Penang and Singapore. Most interesting, however, of these inanimate waifs is a flat piece of black flinty rock hollowed into cup-like pits by the sucking feet of the sea-hedgehog. The pits are excavated as lairs for the animal and some of them are nearly three inches in diameter by one inch deep. To make the rocky bed softer to the feel, the hedgehog has lined it with a calcareous enamel, probably secreted by its body, much in the same way as the pearl oyster coats its shell.

In the earlier days of submarine telegraphy, Sir William Thomson declared the life of a cable to be practically inviolable; and Robert Stephenson, on the other hand, was of opinion that no cable would last out ten years. The latter view has proved the more correct, for the average life of a cable hitherto has been about eleven years. Thanks to the improved means of repairing them, however, the outbreak of faults does not mean the loss of a cable, for these flaws can be cut out in water, however deep, and the cable put to rights again. Indeed every cable company expects a recurrence of faults, and provides a fully-equipped repairing ship always on the spot. A fine model of such a ship is exhibited by the Post Office, after the designs of Mr. R. S. Culley. Messrs. Johnson and Phillips also exhibit a variety of buoys and grapnels for cable operations. The ordinary grapnel is liable to have its prongs broken off in dragging over a rocky bottom, as may be seen from one exhibited which had every prong bent back among the coral reefs of the Brazilian coast. Centipede grapnels are therefore fitted with removable prongs; and Mr. A. Jamieson has invented a grapnel with spring teeth which bend back when they meet a rock, so as to slip over it, but catch and hold the cable. A sample of this grapnel is shown in the Western Gallery, and a sample of Messrs. Johnson and Phillips' grapnel for cutting the cable and holding one end is shown in front of the Roman court, together with a very large buoy for buoying the cable in deep water. A very convenient and novel "mark" buoy for marking positions in cable work is exhibited by the same firm in the Western Gallery. The buoy is suspended by a line from the ship's quarter or stern, and when the line is cut, the buoy drops into the water. The copper float ball (see Fig. 4) is then raised, and lifts a detent which allows the drum of steel wire to revolve. The centipede anchor then sinks to the bottom, and moors the buoy. A winch handle is provided, so that the moorings can be recovered if need be, but the cost of the sinker, drum, and wire is so slight that it may readily be abandoned. While upon the subject of deep-sea operations, we may also mention the "nipper lead" of Mr. Lucas, by which specimens of the sea-bottom are caught in two spoons or tongs hinged to the bottom of the lead, and kept apart by a trigger arrangement, which is sprung by the lead striking the bottom.

Coming now to the working of submarine cables, there are several very neat mirror galvanometers exhibited by Messrs. Latimer Clark, Muirhead, and Co. The Eastern Telegraph Company exhibit the siphon recorder of Sir William Thomson, working through one of Dr. Muirhead's artificial cables on the duplex system, the counter instrument being placed at the stall of the School of Telegraphy. The bold electromagnets of this fine instrument have been excited hitherto by Sir W. Thomson's large tray-form of Daniell cell; but quite recently Mr. Clement Chevallier, electrician to the Eastern Telegraph Company at Aden, has substituted permanent magnets, with a great gain in economy. These magnets were specially made by Mr. Le Neve Foster, at Silvertown, and their magnetic power is much heightened by a small percentage of tungsten in the steel. An interesting experiment, showing the retardation of signals through a long submarine cable, is made by the School of Telegraphy. Ten mirror galvanometers, throwing ten light-spots in a vertical row on a white screen, are connected in turn at different points of a long cable, and the travel of the charge when the circuit is closed by a key is shown by the successive movements of the light-spots across the screen.

Mr. C. F. Varley, F.R.S., who by his application of condensers to the submarine circuit did so much to improve cable signalling, has a very interesting exhibit of his past inventions. These include his gravity battery patented in 1854 (No. 2555), and repatented in 1861 by Menotti, whose name it bears. In the same patent the sulphate of mercury battery, subsequently known as the Mariè-Davy, was also described. This patent, like most of Mr. Varley's, was very rich in devices, and contains his application of the condenser not only to telegraphy, but to electric lighting, a plan subsequently patented by Jablochkoff. Mr. Varley's exhibit also includes the first polarised relay used in this country, and the rotary electrical machine made and patented in 1860, and held by him to be the parent of the Holtz and other induction machines, such as the mousemill of the siphon recorder and the replenisher of the quadrant electrometer. But it is probable that Mr. Varley's claim must give way in favour of M. Belli, who invented a similar induction machine many years ago, which the writer saw in the Retrospective Museum of the recent Paris Electrical Exhibition.

THE EARLIEST USE OF THE INCANDESCENT ELECTRIC LIGHT

A CORRESPONDENT writes:—

The following extract from a memoir by Sir William Grove, published more than thirty-six years ago, will be of interest to future historians of the progress of lighting by electricity. The memoir is entitled "On the Application of Voltaic Ignition to Lighting Mines," by W. N. Grove, F.R.S., and is published in the *Philosophical Magazine*, May, 1845. It begins by stating that M. De la Rive had proposed the use of the voltaic arc for illumi-